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A BIOLOGICAL EVALUATION OF SPRUCE BEETLE ACTIVITY ABAJO MOUNTAINS MANTI-LA SAL NF, MONTICELLO RD

by

John Anhold, Entomologist
Alan Dymerski, Forestry Technician

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ABSTRACT

In 1998, during an aerial detection survey, Englemann spruce, *Picea englemannii* (Perry), mortality was detected in North Creek Canyon, just northwest of Abajo Peak on the Monticello Ranger District, Manti-La Sal National Forest. Follow-up site visits were conducted in the summer of 1999 and several pockets of spruce mortality were found caused by spruce beetle, *Dendroctonus rufipennis* (Kirby). At that time, a request was made to survey the area to determine stand risk to spruce beetle attack and beetle population extent and trend. No spruce mortality was recorded during the 1997 aerial detection surveys.

Ground survey data indicate that spruce mortality is at low levels and static since 1997, however, field observations at mortality centers suggest increasing beetle populations. Five of the twelve stands were found to have beetle activity over the last three years. Spruce mortality levels are generally ten percent or less in stands with spruce beetle activity. Spruce stands surveyed ranged in beetle risk from moderate to moderate-high, with eight of the ten stands in moderate-high risk.

This survey and other site visits indicate spruce beetle populations are increasing and are in the early stages of an outbreak within the surveyed area. Further mortality can be expected in infested and adjacent uninfested stands over the next several years. Uninfested stands that have moderate or higher beetle risk and adjacent to stands with beetle activity are conducive for bark beetle development and spread. It is always difficult to determine if current beetle population levels will escalate to epidemic levels, however, stand conditions within this area are suitable for further development and spread of spruce beetle. If intervention measures are considered within this area they would be most effective while spruce beetle populations are at low levels. Once

beetle populations reach epidemic levels, management options become limited and less successful. In other areas within Utah where stand conditions and beetle populations were similar, early intervention has suppressed beetle related spruce mortality. Successful intervention methods have included salvage logging, sanitation/salvage logging in combination with trap tree, bait tree and/or funnel trap methods.

INTRODUCTION

Spruce beetle, *Dendroctonus rufipennis* (Kirby), is the most serious biotic disturbance agent affecting Englemann spruce, *Picea englemannii* (Perry), throughout its range. Recent spruce beetle activity was first detected on the Manti-LaSal NF, Monticello RD, North Creek Canyon in 1998 by the annual aerial detection survey. A number of recently downed green spruce were observed in some of the current beetle activity centers. These down trees are likely where the current spruce beetle activity started. Monticello District staff requested a biological evaluation of several vegetative units within the Abajo, Horsehead, Twin, and North Peaks area to document current and previous spruce beetle activity and to assess stand and landscape level risk to future spruce beetle attack. Forest Health Protection staff conducted a ground survey of bark beetle-caused mortality in September & October 1999. Twelve mixed Englemann spruce and subalpine fir, *Abies lasiocarpa* (Hooker) Nutt. stands, encompassing approximately 1300 acres, were surveyed, (Figure 1).

Spruce beetles attack mature Englemann spruce in the spruce-fir type in the Central Rockies. Since the late 1800's, populations of this bark beetle have periodically reached outbreak proportions and killed thousands of acres of spruce. Outbreaks often originate as a result of stand disturbances such as windthrow, landslides and avalanches when large diameter green spruce, >16" diameter at breast height (DBH) are knocked down. All such activities can create a favorable environment conducive to spruce beetle infestation and brood development (Schmid and Frye 1977). Beetles are more successful at colonizing green down material because trees no longer produce resins which can pitch out attacking beetles. Beetle survival is also increased in downed material when snow acts as an insulator, preventing low temperatures from killing the brood during winter. Snow also protects the brood from predation by woodpeckers (Schmid 1981).

The spruce beetle generally has a two year life cycle (Furniss and Carolin 1997), however, there is a proportion of the population that could have a one year life cycle. In the two year cycle, which is most commonly found in Utah, the adults attack weakened or windthrown trees in late spring to early summer. Most of the adult flight occurs over a five to six week period beginning in June and ending sometime in early-mid August. Adults of this insect have been found flying in early- to mid-September, but peak flight generally occurs sometime in July. Seasonal temperatures play an important role in the timing and length of beetle development and whether beetles will have a one or two year life cycle. For example, recent research suggests that depending on fall temperatures as much as one third of the beetle population within a given tree could complete their life cycle in one year (personnel communication, Matt Hansen).

Once the eggs are laid, larvae hatch in 10-14 days and begin feeding within the phloem layer of the host tree. The larval stage is the most abundant overwintering stage during the first year of development, although some eggs and parent adults can be present. In the two year life cycle,

larvae pupate approximately one year following initial adult attack. During the second winter of the two year life cycle, callow adults (sexually immature) overwinter in their pupal sites or in the base of the infested tree. Sexually mature adults emerge the following spring, attacking recently-downed or otherwise susceptible spruce with phloem layers capable of supporting larval development. Standing green spruce may also be attacked as beetle population levels increase.

Early detection of new outbreaks can be difficult to detect since trees often do not fade until the second year following attack. In mid- to late-summer of the second year, the needles turn a pale green before falling off the tree. Pitch tubes are not always present on attacked trees; as a result, first year attacks are sometimes only detected by the presence of brown boring dust around the base of the tree or in bark crevices. The evidence of woodpecker feeding, particularly during the winter months when pieces of bark litter the snow, is also an indication of spruce beetle activity.

During endemic years, the spruce beetle primarily attacks windthrown or weakened spruce. Outbreaks are often caused by beetle populations building up in trees affected by stand disturbances and spreading to standing trees. Although this insect will attack trees as small as six to eight inches in diameter, it prefers larger trees in the 16 inch and above diameter classes. These minor disturbances commonly occur in spruce/fir forests and result in partial removal of the overstory or the death of individual trees (Oliver 1981). These types of disturbances create gaps in the canopy allowing the recruitment of subcanopy trees into the main canopy (Veblen et al. 1991).

This report documents the results of our biological evaluation which was designed to determine spruce beetle activity and stand risk. Recommendations and management alternatives will be discussed to reduce potential beetle impacts and improve forest health.

METHODS

Field Procedures

A systematic survey of the spruce/fir type in the Abajo mountains was designed to ensure thorough coverage of stands felt to be at higher risk within the project area. The survey was conducted to determine the residual structure of green stands, stand risk and spruce beetle population extent and trend.

Information on the number of currently infested spruce and uninfested green trees by one-inch dbh classes was gathered using a variable plot cruise. Data on infested trees will indicate the average DBH, percent trees killed and beetle population trend for the area surveyed. All tree species five inches in diameter or greater within the sampling area were tallied. Green stand information can be used to assign a spruce beetle risk rating value to those stands that are not heavily infested by spruce beetle.

Along each survey transect, crews collected data on 157 variable radius plots using a 40 basal area factor (BAF) prism at ten chain intervals (1 chain=66 feet). Distance between plots sometimes varied due to steep terrain. The following information was recorded at each variable radius plot:

1. Tree Species
2. Diameter at Breast Height
3. Tree Condition
    a. Spruce: Green/Uninfested
        Currently Infested (1999)
        Previously Infested (1998)
        Older Infested (1997 and earlier)
        Unknown Mortality
    b. Other Species - Live or Dead
4. Stand Density (Basal Area)

Data Analysis

The data was summarized using the **F**orest **In**sect and **Di**sease **T**ally computer program (FINDIT) (Bentz, In Prep). The following site statistics were calculated using FINDIT: total site live basal area (ft^2/ac); average live quadratic mean diameter (QMD) for spruce; average QMD for spruce larger than 10 inches DBH; percent basal area (BA); tree species composition; percent basal area spruce mortality caused by spruce beetle for 1999, 1998 and 1997, and percent total basal area spruce mortality.

Stand susceptibility was assessed using the risk rating system developed by Schmid and Frye (1976) described in Table 1. It is based on physiographic location, average QMD of live spruce >10 inches DBH, stand basal area and proportion of spruce in the canopy. A stand risk map was created using summarized data (Figure 2). In all stands a site index of 40-80, base age 100, was used for determining the risk variable for the physiographic location.

RESULTS

A total of 157 variable radius plots were measured within 12 stands encompassing approximately 1300 acres. Four tree species were tallied in this survey, Englemann spruce, subalpine fir, aspen (*Populus tremuloides* Mich.), and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco.).

For the 12 stands surveyed, live stand basal area averaged 223 ft^2/ac, with a range from 142 to 268 ft^2/ac. The average BA for the residual species composition was 71% spruce, 25% subalpine fir, 4% aspen and less than 1% Douglas-fir. The live spruce component ranged from 37% to 94% basal area within surveyed stands. The average DBH for spruce is 18 inches and the average DBH for spruce >10 inches is 20 inches, Table 2.

Englemann spruce mortality is primarily in the 19+ inch DBH classes. The average spruce mortality expressed as percent BA was seven percent for stands with spruce beetle activity. Four stands were rated moderate risk and the others were moderate-high risk (Figure 2).

DISCUSSION

The information collected in the Abajo mountains summarizes current spruce beetle activity and associated stand risk. Since 1997, spruce beetle populations have increased and are expanding into adjacent green spruce from current beetle mortality centers.

Spruce beetle is a major mortality factor in unmanaged mature stands of Englemann spruce. During outbreaks, the insect removes the dominant and codominant live spruce component. This can change the stand composition to a higher percentage of non-host species and less susceptible spruce (smaller diameter trees). Subalpine fir is also a major component (average 25 percent of the stands BA) within these spruce/fir stands. As the insect removes the spruce overstory, many of these sites will revert to a subalpine fir overstory with a mixed subalpine fir/spruce understory.

Risk ratings are generally used to determine a stand's susceptibility to spruce beetle infestation. Because the insect is already present in a number of the stands surveyed, stand risk can be used to determine where additional losses could occur in adjacent uninfested stands. Most of the additional mortality will occur in stands rated moderate and higher risk.

Based on this survey, personnel observations and the annual aerial insect detection surveys, spruce beetle populations are expected to continue to increase and spread to adjacent uninfested trees and stands. Spruce trees attacked in 1998 will have emerging adults in the spring of 2000. It appears that the main beetle flight is on even years.

MANAGEMENT ALTERNATIVES

NO ACTION. This alternative would allow the infestation to continue and accept future losses until the infestation collapses naturally. Estimates of stand losses can be approximated using beetle population surveys. Down and standing dead will increase fuel loads and visual quality will decrease as a result of the no action alternative. Within the North Creek project area, the beetle population is at pre-outbreak levels and expected to increase. Additional mortality of the residual spruce component will probably occur and mortality levels could exceed 70 percent of the spruce basal area in some stands within this survey area.

Silvicultural Methods:

DIRECT SUPPRESSION. This could include individual tree treatment at campgrounds, administrative sites, trail heads and at other sites with high value trees. This may include: removal of infested trees, treating susceptible trees with a chemical insecticide, or felling and burning or peeling infested trees. Individual tree treatment is often labor intensive and expensive. These treatments are effective only in small infestations with isolated pockets of beetle activity with good vehicle access.

SALVAGE LOGGING. Both currently infested and dead trees would be removed. This alternative would utilize the dead material and assist in suppressing localized populations of the insect. In large infestations at epidemic levels, suppressing insect populations using this alternative is not practical. However, in smaller, building populations this alternative has been an effective suppression strategy. This alternative does not significantly change stand conditions that influence stand susceptibility to spruce beetle attack.

SANITATION/SALVAGE LOGGING. This alternative combines removal of dead and infested trees, and the susceptible uninfested trees in a stand. Schmid and Frye (1977) maintain that for infested stands, if the allowable cut in a given stand is more than the basal area represented by all infested and susceptible spruce, all those trees should be removed. If total basal area of infested and susceptible spruce is greater than the recommended cut, the manager has three options: 1) remove all susceptible trees; 2) remove the recommended basal area in infested, susceptible trees, accepting the risk of future losses; or 3) leave the stand uncut. If the stand is cut, windthrow could be left as trap trees and removed once infested.

TRAP TREES. Large diameter, >16" dbh, green spruce are felled before beetle flight to absorb beetles. Trap trees can absorb up to 10 times the number of spruce beetles compared to standing trees. Once infested, trap trees should be removed from the forest or brood destroyed using fire, or peeling, following beetle flight the same year infestated. Trap trees shaded from direct sunlight attract the most beetles, thus felled trees should not be limbed.

I would recommend a 1:3 to 1:5 trap tree to currently infested tree ratio for the building beetle population in the Abajo mountains. The ratios vary with the size of the green trees felled as traps, the number and size of infested trees and the existing beetle population. Trap trees felled adjacent to standing host trees may result in adjacent trees becoming infested. Felling trap trees in sites where more abundant non-host or standing adjacent spruce are smaller in diameter (<10" dbh) will reduce the number of residual spruce attacks. Again, trap trees and infested standing spruce should be removed following the current year spruce beetle flight.

Physical Methods:

FIRE. This involves felling, piling and burning infested material to destroy inhabiting broods. The infested material is usually green and difficult to burn, but the bark has to be completely burned to destroy the inhabiting brood. This method is labor intensive, expensive and typically used in conjunction with trap trees or bait trees when they can not be removed from the site.

Chemical Methods:

PHEROMONES. This method uses chemical substances that influence insect behavior. Synthetic aggregating pheromones increase the attractiveness of trap trees, attract beetles into the trees to be cut or where beetle broods can be destroyed.

> Baiting - This method uses attractant pheromones placed on standing green spruce to attract beetles into a tree, similar to the trap tree method. Cluster baiting is most effective, baiting three trees spaced at 50 to 100 foot intervals in a triangle for every 10-20 infested spruce. Where possible bait trees close to infested clumps (within 100-200

feet) or within clumps of infested host material. Baiting will result in attacks on adjacent susceptible host trees. It is not uncommon to have five to ten adjacent spruce attacked from each cluster of baited spruce. Baited and surrounding standing infested trees should be removed the first year of attack similar to the recommendations for trap trees.

Funnel Traps - This method uses an attractant pheromone in conjunction with a funnel trap to capture and reduce the resident beetle population. Baited funnel traps should be placed adjacent to infested spruce but in non-host material whenever possible. This will help reduce the number of green residual spruce that are attacked as a result of the funnel traps. If the infested cluster of spruce is larger than 20 trees, place the funnel traps in the center of the infested group. Similar to tree baiting, funnel traps should be used in clusters of three traps, spaced at 50 foot intervals for every 15-20 infested spruce. Funnel traps should be emptied at least once a week. This technique is most effective when used in combination with other treatments.

INSECTICIDES. Insecticides such as carbaryl can be applied to the bole of uninfested trees to kill attacking adult beetles. Insecticide application is typically targeted at high value trees such as those in campgrounds, trailheads, and around administrative sites. Each individual tree must be treated to a height of 45-50 feet up the bole. Trees must be treated so the material is running down the bole to adequately covered all bark crevices. All bole surfaces, including the root collar, must be treated with the insecticide. Failure to ensure thorough coverage will result in strip attacks and attacks near the base of the tree. Insecticide applications for spruce beetle should be applied in the fall. Proper applications can afford protection for two years from beetle attacks.

CONCLUSION

Because of the current level of insect activity in the Abajo Mountains and the moderate to moderate-high stand risk, beetle-related spruce mortality is expected to increase within the area over the next several years. As beetle populations continue to increase they could move into adjacent uninfested spruce/fir stands. Stands with similar beetle risk levels in Utah have sustained 40-90 percent spruce basal area mortality once beetle populations reached outbreak levels.

Selecting a sanitation/salvage logging alternative would reduce insect activity, stand risk and potential future losses within these areas while beetle populations are still at the pre-outbreak level. The use of felled trap trees, baited trees and/or funnel traps to collect emerging adult beetles will help suppress beetle population levels. Insecticides can be a very effective tool at reducing individual spruce mortality. Insecticides do not reduce stand susceptibility and should not be used as a landscape treatment for bark beetles.

Removal of only infested trees in conjunction with trap trees, baited trees and/or funnel traps will not significantly change stand susceptibility. These methods have effectively reduced pre-epidemic beetle populations when infested trap trees and infested spruce are removed from the site. These methods are less successful when infested trees must be felled and burned or felled and peeled.

In stands not infested with spruce beetle, a sanitation logging alternative may alter the stand structure to reduce beetle losses. Removing susceptible spruce will reduce basal area and lower spruce diameters. Thinning may be more effective if inter-tree spacing is maintained and clumps of spruce are not left to meet basal area objectives. Thinning strategies designed to mimic the low risk parameters described by Schmid & Frye (1977) will reduce the stand attributes favorable for beetle development and spread. If a silvicultural treatment is selected, spruce beetle management guidelines, outlined in the Appendix, can be followed.

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Table 1. Risk categories for potential spruce beetle outbreaks for each stand characteristic.

Risk category[1]	Physiographic location	Average diameter of live spruce above 10 inches d.b.h.	Basal area	Proportion of spruce in canopy
		Inches d.b.h.	*Ft^2*	*Percent*
High (3)	Spruce on well-drained sites in creek bottoms	> 16	> 150	> 65
Medium (2)	Spruce on sites with site index of 80 to 120	12-16	100-150	50-65
Low (1)	Spruce on sites with site index of 40 to 80	< 12	<100	<50

[1]Number in parentheses indicates arbitrary value to be used in calculating stand priority, and is used only for convenience.

Stand Risk Value	**Potential Outbreak Rating**
11- 12	High
10	High/Intermediate
7-9	Medium
6	Intermediate/Low
4-5	Low

Table 2. Summary statistics for the Abajo Mountains spruce survey, Monticello RD, Manti La-Sal NF.

Stand	Avg Age	Live Std	Avg live	Avg Live ES	% ES	% SAF	% QA	% DF	1999	1998	1997	Total	Risk
	ES	BA	ES DBH	DBH> 10"	BA	BA	BA	BA	ES Mort.	ES Mort.	ES Mort.	ES Mort.	Rating
A	154	142	15	17	37	47	16	0	0	0	0	0	7 Mod
B	136	243	20	21	64	32	4	0	0	0	0	0	9 Mod
C	159	214	20	20	71	25	4	2	0	0	0	0	10 M-H
D	230	240	18	20	71	25	2	0	2	1	2	5	10 M-H
E	204	201	19	20	77	23	0	0	0	0	0	0	10 M-H
F	192	268	17	20	91	9	0	0	0	3	0	3	10 M-H
G	145	247	21	21	63	31	6	0	0	0	0	0	9 Mod
H	164	173	19	18	46	41	13	0	0	0	0	0	8 Mod
I	163	272	18	23	94	6	0	0	0	0	0	0	10 M-H
J	238	242	16	18	73	26	1	0	0	0	1	1	10 M-H
K	202	240	19	21	77	23	0	0	0	0	4	4	10 M-H
L	188	196	15	18	93	7	0	0	10	6	8	24	10 M-H
AVG	181	223	18	20	71	25	4	0	1	1	1	3	

ES – Englemann spruce
SAF – Subalpine fir
QA – Quaking Aspen
DF- Douglas-fir
DBH –diameter at breast height
BA – square feet of basal area per acre

Figure 1. Twelve stands surveyed in the summer of 1999 for spruce beetle activity on the Monticello RD, Manti LaSal NF. Numbered points are the approximate location of survey plots.

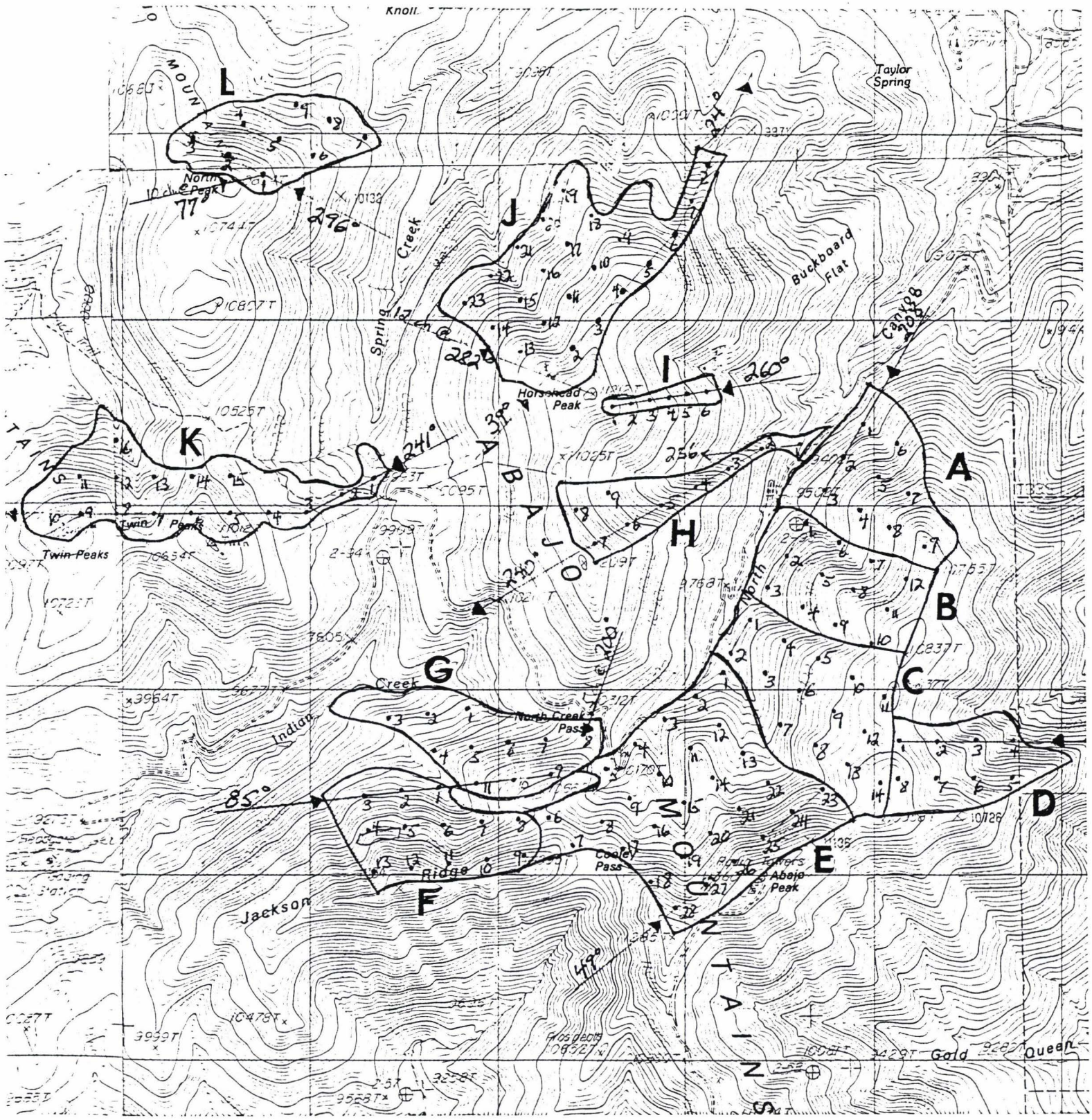
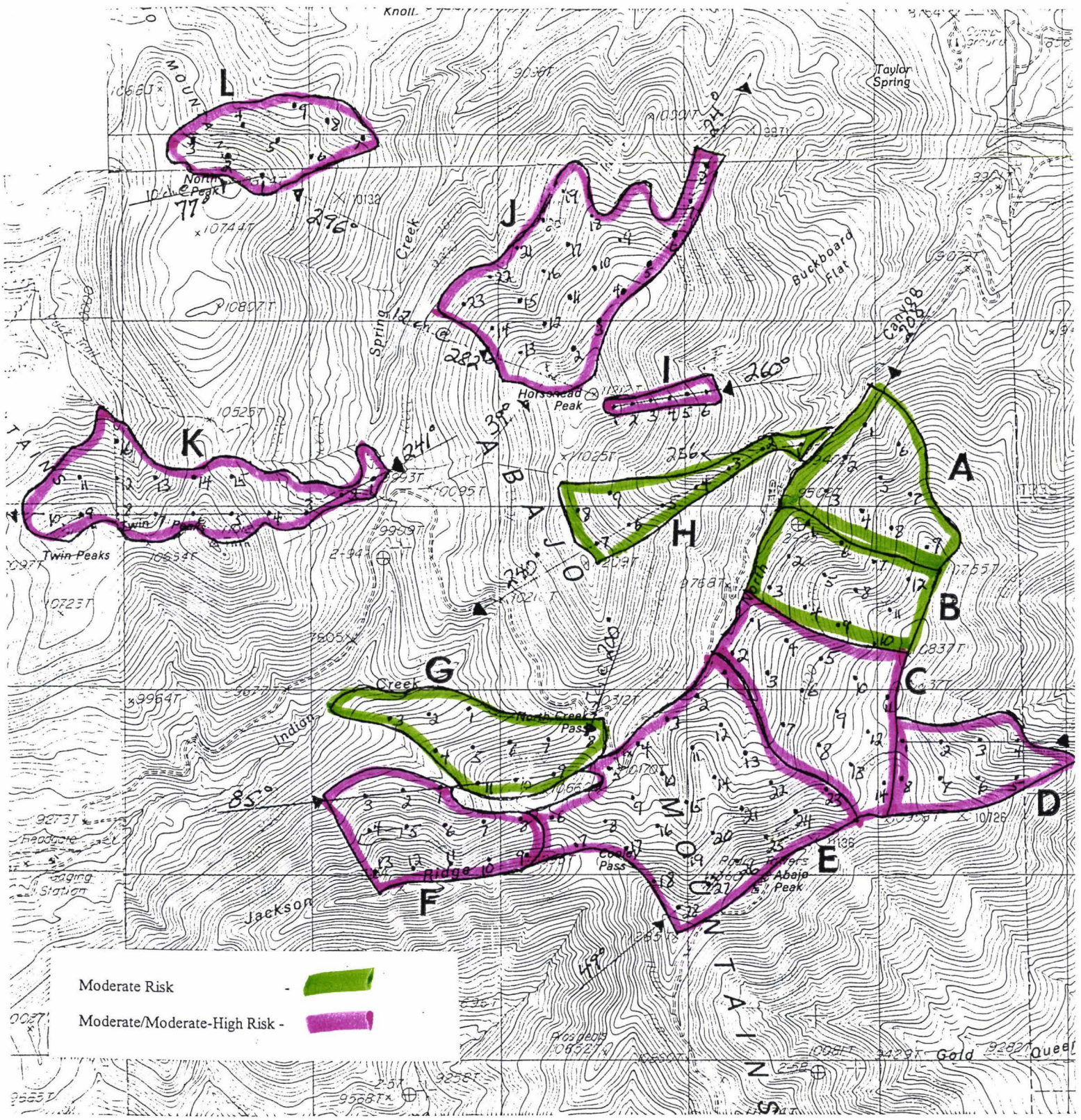


Figure 2. Spruce beetle risk for stands surveyed in the Abajo Mountains, Monticello RD, Manti LaSal NF.



SPRUCE BEETLE MANAGEMENT

Stand susceptibility to spruce beetle infestation can be reduced by converting the stand to less susceptible attributes favorable to beetle development. This requires reducing the average spruce diameter to less than 12 inches DBH, reducing the basal area of the stand to under 100 square feet per acre and increasing the non-host species component of the stand.

To prevent population increases and subsequent outbreaks in all harvesting and cutting operations (including normal timber harvest, sanitation/salvage cutting, cutting for road right-of-ways and construction), all slash, cull, and butt logs should be treated as described. Spruce should be cut as low to the ground as possible to reduce stump height, at a minimum 18 inches. Complete removal or destruction of large diameter (>10 inches) logs, tops, and branches will prevent buildup of bark beetles (see Contract Provision C6.429#). If removal of large-diameter slash including infested, snow broken or windthrown trees is not possible within 12 to 18 months of when the infestation or damage first occurs, the slash should be cut into small pieces (<18 inches in length) and scattered into areas receiving maximum sunlight. This procedure drys up the phloem layer at a faster rate which can affect successful development of the insect brood. The cut bolts can be burned to destroy the brood.

To further reduce spruce beetle populations, a trap tree method may be employed. This includes felling uninfested green trees adjacent to beetle-infested centers. Beetles prefer down material and the infested material can then be removed with harvest. A variation of the trap tree is the use of attractive pheromones to lure beetles to green trees. Pheromones are placed on the north side of the bole of large merchantable trees at densities mentioned earlier. Forest Health Protection staff would be available to assist in implementing a trap tree program.

Silvicultural treatments require a mutli-year commitment with 3-5 years of careful management to reduce spruce beetle populations to endemic levels. Because of the explosive nature of spruce beetle populations no treatment guarantees complete protection once an outbreak develops, however, employing these strategies provides the best option.

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